STUDIES ON GASEOUS TRANSFER BETWEEN THE COLON AND BLOOD STREAM IN MAN

BY

ROBERT SEYMOUR POGRUND

B. S., Central Y. M. C. A. College, 1942

M. S., University of Illinois, 1944

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSIOLOGY
IN THE GRADUATE SCHOOL OF THE
UNIVERSITY OF ILLINOIS, 1947

URBANA, ILLINOIS

1947

STUDIES ON GASEOUS TRANSFER BETWEEN THE COLON AND BLOOD STREAM IN MAN

BY

ROBERT SEYMOUR POGRUND

B. S., Central Y. M. C. A. College, 1942

M. S., University of Illinois, 1944

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSIOLOGY
IN THE GRADUATE SCHOOL OF THE
UNIVERSITY OF ILLINOIS, 1947

URBANA, ILLINOIS

1947

ACKNOWLEDGMENT

The author wishes to express his deepest gratitude and appreciation to Professor F. R. Steggerda for his direction, guidance and encouragement and for creating in him a critical attitude toward research during these investigations.

R. UNIV. BIBLIOTHEEK LEIDEN

STUDIES ON GASEOUS TRANSFER BETWEEN THE COLON AND BLOOD STREAM IN MAN

Introduction

The behavior of gases in the gastro-intestinal tract has been the subject of several studies, and it is generally concluded that the atmospheric air entering the stomach during swallowing and the gases arising in the intestinal tract by fermentation are modified by interchange with the gases of the blood stream. The present work was undertaken to supply data relative to the following factors:

(1) The physical principles governing the transfer of gas in the colons of human subjects.

(2) The utilization of these physical principles in interpreting the beneficial effects of oxygen inhalation toward the relief of intestinal distension, such as would occur post-operatively or during high altitude flying.

(3) The effects of gases in the colon on the quantitative output of oxygen and carbon dioxide in the alveolar air.

Experimental

PART I

The absorptions of oxygen as contained in room air and of carbon dioxide as contained in a mixture with nitrogen were studied by introducing 500 c. c. volumes into the colons of normal healthy adult subjects by way of an open tipped rubber tube inserted into the rectum. Gas samples were withdrawn at various intervals of time and analyzed for oxygen, carbon dioxide, methane, hydrogen, and nitrogen being determined by difference.

The type of progressive absorption appears to follow an exponential curve until an equilibrium is reached when the

partial pressure of the gas in the lumen is equal to the mean tension of the gas dissolved in the circulating venous blood. This condition of equilibrium is the same, regardless of the direction from which it is approached, that is, either from lumen into the blood or from blood into the lumen.

An equation to fit such an exponential curve would have to be of the type $P = ae^{-kt} + c$, where P is the pressure, a is the effective initial pressure gradient, e indicates natural logs, k is the absorption coefficient, t is time in minutes, and c is a constant determining the limits of the curve and is assumed to be the gas tension in physical solution in the venous blood. These components of the equation are all experimentally determined, thereby making possible the calculation of the absorption coefficient, the k value, of the particular gas studied. The k values can then be compared with those k values determined by McIver and coworkers (1) on the basis of theoretical considerations. The c component of the equation is determined by the analysis of alveolar gas which has been equilibrated with those gas tensions of the mixed venous blood by a special breathing technique.

The average exponential equation of ten experiments for the absorption of oxygen is $P = 17.13e^{-.01658t} + 3.52$, indicating the average tension of oxygen in venous blood to be 3.52% of one atmosphere (27 mm Hg) which approximates the tension of oxygen within the lumen of the colon. The k value of —.01658 agrees favorably with the average k value of —.01638, calculated by McIver's equation.

The average exponential equation of ten experiments for the absorption of carbon dioxide is $P = 13.89e^{-.02884t} + 6.86$, indicating the average tension of carbon dioxide in venous blood to be 6.86% of one atmosphere (52 mm Hg) approximating the tension of this gas within the lumen of the colon. The k value of —.02884 agrees less favorably in this case with the average k value of —.03040 calculated by McIver's equation, presumably because of the production of

carbon dioxide by the intestinal flora.

PART II

The principles underlying the gas absorption process having been studied, it was of practical interest to determine the manner in which these principles might be applicable in helping to better understand the problem that has confronted aviation physiologists, namely, the distension in the gastro-intestinal tract resulting during high altitude flying.

Nitrogen is not significantly absorbed, not only because of its low diffusion constant, but also because the blood is already saturated with this gas existing under a partial pressure of 4/5 of an atmosphere. The effect of lowering the nitrogen tension in the blood on the absorption of nitrogen from the colon was studied by introducing 500 c. c. of nitrogen into the colon and noting the percentage volume of gas recovered at the end of two hours while breathing room air to serve as controls as opposed to breathing pure oxygen for removal of nitrogen from the blood, comprising the experimental study. The percentage volume gas recoveries under oxygen inhalation as compared to the controls indicate that the removal of nitrogen from the blood sets up a pressure gradient favorable for the absorption of this gas from the colon. The average percentage volume recovered in the control group was 129.2% as compared to 43.9% for the oxygen inhalation group, the difference between both groups being very highly significant.

PART III

When pure carbon dioxide is contained in the colon, the degree of absorption is so rapid as to result in a mild upset in acid-base balance in the blood stream. The shift in pH is toward the acid side as manifested by an average two per cent increase over normal in oxygen content of alveolar gas, indicating a decreased affinity of hemoglobin for oxygen.

Summary

The absorption rate of gas from the human colon depends upon the partial pressure gradient existing between the lumen of the colon and the mixed venous blood. Removal of nitrogen from the blood stream by pure oxygen inhalation produces a pressure gradient favorable for the absorption of nitrogen from the intestinal tract. Pure carbon dioxide is absorbed from the colon with sufficient rapidity as to cause a mild upset in acid-base balance.

BIBLIOGRAPHY

(1) McIver, M. A., Redfield, A. C., and Benedict, R. B., American Journal of Physiology, **76,** 92 (1926).

VITA

The author was born September 28, 1920, in Chicago, Illinois, where he attended the public grammar and high schools. He enrolled at Wright Junior College, receiving a bronze award for scholastic achievement. He then matriculated at the Central Y. M. C. A. College, receiving a Bachelor of Science degree in June, 1942, with a major in Chemistry and minors in Physics and Zoology. A laboratory assistantship was held during the last semester at the Central Y. M. C. A. College in the fields of Physiology and Histology. He was then employed by the International Harvester Company as a plant control chemist in August, 1942, to March, 1943, and by the Illinois State Geological Survey as a research assistant in Chemistry in March, 1943, to February, 1944. He matriculated in the graduate school of the University of Illinois in June, 1943, and was appointed as a research assistant in the Department of Biochemistry in June, 1944, until the present time. The degree of Master of Science in Physiology was awarded in October, 1944, for presentation of the thesis entitled "The Effects of Low Atmospheric Pressure on Metabolic Rates in Frogs."

Published writings include "The Influence of Various Gases Contained in the Colon on Colon Motility," Anatomical Record, **94,** 36 (1946), and "A Study of the Behavior of Various Gases when Placed in the Colon of Man," Federation Proceedings, **6,** 180 (1947).

Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41549815_0064